

# ÍNDICE GENERAL

	Pág.
<b>AGRADECIMIENTOS .....</b>	<b>iii</b>
<b>ÍNDICE GENERAL .....</b>	<b>vi</b>
<b>ÍNDICE DE TABLAS .....</b>	<b>ix</b>
<b>ÍNDICE DE FIGURAS .....</b>	<b>x</b>
<b>RESUMEN .....</b>	<b>xii</b>
<b>ABSTRACT .....</b>	<b>xiv</b>
<b>RESUM .....</b>	<b>xvi</b>
<b>CAPÍTULO 1 .....</b>	<b>1</b>
<b>1    INTRODUCCIÓN.....</b>	<b>2</b>
<b>1.1    Antecedentes.....</b>	<b>2</b>
<b>1.2    Contexto de la investigación.....</b>	<b>4</b>
1.2.1    Contexto general .....	4
1.2.2    Contexto específico .....	8
1.2.3    Objetivos de la investigación.....	16
<b>1.3    Métodos de investigación.....</b>	<b>16</b>
<b>1.4    Estructura general de la investigación.....</b>	<b>19</b>
<b>1.5    Referencias .....</b>	<b>21</b>
<b>CAPÍTULO 2 .....</b>	<b>25</b>
<b>2    TRENDS IN THE MULTI-CRITERIA ASSESSMENT OF THE SOCIAL SUSTAINABILITY OF INFRASTRUCTURES.....</b>	<b>26</b>
<b>2.1    Social sustainability in infrastructures.....</b>	<b>27</b>
<b>2.2    Muti-criteria assessment methods.....</b>	<b>30</b>
<b>2.3    Point of departure .....</b>	<b>32</b>
<b>2.4    Research method .....</b>	<b>32</b>
<b>2.5    Results .....</b>	<b>33</b>
2.5.1    Relevant social aspects in the infrastructure assessment .....	34
2.5.2    Participants in the process of social assessment of infrastructures.....	37
2.5.3    Multi-criteria methods for social assessment of infrastructure.....	38
2.5.4    Equity, learning and context in the social assessment of infrastructures.....	41
<b>2.6    Discussion .....</b>	<b>44</b>
<b>2.7    Conclusions.....</b>	<b>46</b>
<b>2.8    References.....</b>	<b>47</b>
<b>CAPÍTULO 3 .....</b>	<b>54</b>
<b>3    SOCIAL SUSTAINABILITY IN THE LIFE CYCLE OF CHILEAN PUBLIC INFRASTRUCTURE .....</b>	<b>55</b>
<b>3.1    Introduction.....</b>	<b>56</b>
<b>3.2    Social sustainability factors and criteria.....</b>	<b>58</b>
<b>3.3    Research method .....</b>	<b>60</b>
3.3.1    The Delphi method.....	61

3.3.2	Selection of the expert panel .....	62
3.3.3	Questionnaire and measurement instrument.....	64
3.3.4	Survey process.....	65
<b>3.4</b>	<b>Results .....</b>	<b>65</b>
<b>3.5</b>	<b>Discussion .....</b>	<b>67</b>
<b>3.6</b>	<b>Conclusions.....</b>	<b>69</b>
<b>3.7</b>	<b>References.....</b>	<b>70</b>
<b>CAPÍTULO 4.....</b>		<b>75</b>
<b>4 APPRAISAL OF INFRASTRUCTURE SUSTAINABILITY BY GRADUATE STUDENTS USING AN ACTIVE-LEARNING METHOD .....</b>		<b>76</b>
<b>4.1</b>	<b>Introduction.....</b>	<b>77</b>
<b>4.2</b>	<b>Methods .....</b>	<b>79</b>
<b>4.3</b>	<b>Selection of criteria for sustainability .....</b>	<b>81</b>
<b>4.4</b>	<b>Practical implementation .....</b>	<b>81</b>
<b>4.5</b>	<b>Assessment of the process.....</b>	<b>91</b>
<b>4.6</b>	<b>Discussion .....</b>	<b>93</b>
<b>4.7</b>	<b>Conclusions.....</b>	<b>96</b>
<b>4.8</b>	<b>References.....</b>	<b>97</b>
<b>CAPÍTULO 5.....</b>		<b>102</b>
<b>5 METHOD FOR ESTIMATING THE SOCIAL SUSTAINABILITY OF INFRASTRUCTURE PROJECTS.....</b>		<b>103</b>
<b>5.1</b>	<b>Introduction.....</b>	<b>104</b>
<b>5.2</b>	<b>Point of departure .....</b>	<b>105</b>
<b>5.3</b>	<b>Objectives of the research .....</b>	<b>106</b>
<b>5.4</b>	<b>Proposed method .....</b>	<b>107</b>
5.4.1	Selection and weighting of social criteria and goals (A0, A1, B0, B1).....	108
5.4.2	Scoring of social improvement criteria and goals (A.2, B.2) .....	110
5.4.3	Assessment of the short-term social criteria (A.3) .....	114
5.4.4	Short and long-term social improvement indices (A.5, B.4).....	114
5.4.5	Socially sustainable solutions (C.1, C.2).....	115
<b>5.5</b>	<b>Case study.....</b>	<b>116</b>
5.5.1	Social improvement criteria and goals .....	116
5.5.2	Description of the alternatives of infrastructure projects.....	118
5.5.3	Contribution to short-term social improvement .....	121
5.5.4	Contribution to long-term social improvement .....	124
5.5.5	Outcomes from the method .....	125
<b>5.6</b>	<b>Discussion .....</b>	<b>126</b>
<b>5.7</b>	<b>Conclusions.....</b>	<b>127</b>
<b>5.8</b>	<b>References.....</b>	<b>128</b>
<b>CAPÍTULO 6.....</b>		<b>132</b>
<b>6 ASSESSING THE SOCIAL SUSTAINABILITY CONTRIBUTION OF AN INFRASTRUCTURE PROJECT UNDER CONDITIONS OF UNCERTAINTY .....</b>		<b>133</b>
<b>6.1</b>	<b>Introduction.....</b>	<b>134</b>
<b>6.2</b>	<b>Dealing with uncertainty .....</b>	<b>136</b>
<b>6.3</b>	<b>Estimation method of the social sustainability of infrastructures .....</b>	<b>137</b>
<b>6.4</b>	<b>Treatment of uncertainty proposed for the assessment of social sustainability of infrastructures .....</b>	<b>139</b>
6.4.1	Distribution of the weights of the method (A.1, A.2.2, B.1, B.2.2).....	140
6.4.2	Preparation of the uncertain variables ( $r_i$ ) and indicators ( $v_k$ ) (A.2.1 – B.2.1) .....	140

6.4.3	Assessment scenarios of the short-term social criteria (A.3).....	141
6.4.4	Propagation of uncertainty in the method to obtain the social improvement indices (A.4, B.4) 141	
6.4.5	Determination of probability of each prioritized alternative (C.1).....	142
<b>6.5</b>	<b>Case study.....</b>	<b>142</b>
6.5.1	Structure for decision-making .....	142
6.5.2	Description of the alternatives of infrastructure projects.....	144
6.5.3	Treatment of uncertainty in the case study .....	147
<b>6.6</b>	<b>Conclusions.....</b>	<b>152</b>
<b>6.7</b>	<b>References.....</b>	<b>153</b>
<b>CAPÍTULO 7 .....</b>		<b>156</b>
<b>7</b>	<b>BAYESIAN NETWORK METHOD FOR MAKING DECISIONS ABOUT SOCIAL SUSTAINABILITY OF INFRASTRUCTURE PROJECTS.....</b>	<b>157</b>
<b>7.1</b>	<b>Introduction.....</b>	<b>158</b>
<b>7.2</b>	<b>Bayesian network applied to decisión-making.....</b>	<b>160</b>
<b>7.3</b>	<b>Proposed method.....</b>	<b>161</b>
7.3.1	Preparation of the decision-making model (Stage 1).....	163
7.3.2	Formulation of the decision-making model (Stage 2) .....	165
7.3.3	Optimization of infrastructure projects (Stage 3) .....	167
<b>7.4</b>	<b>Case study.....</b>	<b>168</b>
7.4.1	Preparation of the decisión-making model for the case study .....	169
7.4.2	Formulation of the decision-making model for the case study.....	174
7.4.3	Optimization of road projects.....	175
<b>7.5</b>	<b>Discussion .....</b>	<b>177</b>
<b>7.6</b>	<b>Conclusions.....</b>	<b>178</b>
<b>7.7</b>	<b>References.....</b>	<b>179</b>
<b>CAPÍTULO 8 .....</b>		<b>183</b>
<b>8</b>	<b>DISCUSION GENERAL DE LOS RESULTADOS.....</b>	<b>184</b>
<b>8.1</b>	<b>Estructura general de los resultados de investigación .....</b>	<b>184</b>
<b>8.2</b>	<b>Discusión general de los resultados de investigación. ....</b>	<b>186</b>
<b>8.3</b>	<b>Referencias .....</b>	<b>192</b>
<b>CAPÍTULO 9 .....</b>		<b>196</b>
<b>9</b>	<b>CONCLUSIONES.....</b>	<b>197</b>
<b>9.1</b>	<b>Contribución de la investigación.....</b>	<b>197</b>
<b>9.2</b>	<b>Recomendaciones .....</b>	<b>199</b>
<b>9.3</b>	<b>Limitaciones .....</b>	<b>201</b>
<b>9.4</b>	<b>Futuras líneas de investigación .....</b>	<b>204</b>
<b>9</b>	<b>CONCLUSIONS .....</b>	<b>207</b>
<b>9.1</b>	<b>Research contributions.....</b>	<b>207</b>
<b>9.2</b>	<b>Recommendations .....</b>	<b>209</b>
<b>9.3</b>	<b>Limitations .....</b>	<b>211</b>
<b>9.4</b>	<b>Future lines of research.....</b>	<b>214</b>
<b>REFERENCIAS .....</b>		<b>217</b>
<b>ANEXOS .....</b>		<b>234</b>
<b>Anexo A: PORTADA DE ARTÍCULOS PÚBLICADOS .....</b>		<b>235</b>
<b>Anexo B: MATERIAL SUPLEMENTARIO DEL CAPITULO 2 .....</b>		<b>239</b>

## ÍNDICE DE TABLAS

<b>Table 2.1: Summary of the main multi-criteria assessment methods.....</b>	<b>31</b>
<b>Table 2.2: Social criteria.....</b>	<b>34</b>
<b>Table 2.3: Evolution of social criteria by year .....</b>	<b>35</b>
<b>Table 3.1: Evolutionary sample of studies that integrate at least 40 % coverage of social impacts...59</b>	
<b>Table 3.2: Formulation of coefficients for panel self-evaluation .....</b>	<b>63</b>
<b>Table 3.3: Characterization of the expert panel .....</b>	<b>63</b>
<b>Table 3.4: Competence coefficients of the expert panel.....</b>	<b>64</b>
<b>Table 3.5: Agreement and importance of the social sustainability criteria at the lifecycle stages ....66</b>	
<b>Table 4.1: Reference criteria of sustainability used in implementing the method (Adapted from Labuschagne et al. 2005) .....</b>	<b>81</b>
<b>Table 4.2: The participatory process layout .....</b>	<b>83</b>
<b>Table 4.3: Background of the process participants.....</b>	<b>83</b>
<b>Table 4.4: Extract of comparative appraisal survey (base don Saaty (1987) .....</b>	<b>85</b>
<b>Table 4.5: Background of case studies 1 and 2.....</b>	<b>88</b>
<b>Table 4.6: Prioritized projects for the student teams.....</b>	<b>89</b>
<b>Table 4.7: The key considerations that students took into account .....</b>	<b>90</b>
<b>Table 4.8: Sensitivity analysis per profile at the stage of operation of the infrastructure for both case studies .....</b>	<b>91</b>
<b>Table 4.9: Learning outcomes through the application of the assessment rubric .....</b>	<b>92</b>
<b>Table 4.10: Results of the learning process through the applications of a survey .....</b>	<b>93</b>
<b>Table 5.1: AHP questionnaire sample applied to the experts .....</b>	<b>110</b>
<b>Table 5.2: Characteristics of the expert panel of the case study “El Salvador” .....</b>	<b>117</b>
<b>Table 5.3: Synthesis of the background of the alternatives for short-term evaluation .....</b>	<b>120</b>
<b>Table 5.4: Synthesis of the zone’s current situation for long-term evaluation .....</b>	<b>121</b>
<b>Table 5.5: Transfer functions for "employment" and "safe environment" social criteria .....</b>	<b>122</b>
<b>Table 5.6: Aspects that determine the social contribution of the variable “r” .....</b>	<b>123</b>
<b>Table 5.7: Results of social improvement from short-term infrastructure alternatives.....</b>	<b>124</b>
<b>Table 5.8: Results of long-term social improvement.....</b>	<b>124</b>
<b>Table 5.9: Stability of variables “Weight-Wi Wk” for the solution set .....</b>	<b>126</b>
<b>Table 6.1: Short-term decision-making structure of the case of study .....</b>	<b>143</b>
<b>Table 6.2: Location background of assessment contexts .....</b>	<b>145</b>
<b>Table 6.3: Synthesis of the background of the alternatives for short-term evaluation with uncertain criteria .....</b>	<b>145</b>
<b>Table 6.4: Correlation of short-term social criterion weights.....</b>	<b>148</b>
<b>Table 6.5: Order of priority of infrastructure alternatives.....</b>	<b>151</b>
<b>Table 7.1: Characteristics of selected experts .....</b>	<b>169</b>
<b>Table 7.2: Decision variables of the road project and context that contribute to social sustainability .....</b>	<b>172</b>
<b>Table 7.3: Conditional probability of “Accessibility to schools” and “Improvement in education” with respect to “School attendance” .....</b>	<b>173</b>
<b>Table 7.4: Sample of non-inferior alternatives with higher social contribution mean.....</b>	<b>177</b>

# ÍNDICE DE FIGURAS

<b>Figura 1.1: Localización de infraestructuras con registro de conflictos sociales en 1er y 2do nivel de importancia .....</b>	<b>5</b>
<b>Figura 1.2: Formas de movilización de los grupos afectados.....</b>	<b>6</b>
<b>Figura 1.3: Impactos sociales de los proyectos de infraestructuras.....</b>	<b>6</b>
<b>Figura 1.4: Relación de los capítulos constituyentes de la tesis .....</b>	<b>10</b>
<b>Figura 1.5: Estructura general de la investigación .....</b>	<b>20</b>
<b>Figure 2.1: Relationship of the elements considered in the social sustainability assessment process for this study.....</b>	<b>30</b>
<b>Figure 2.2: Initial search strategy .....</b>	<b>33</b>
<b>Figure 2.3: Methodological cycle of the review .....</b>	<b>33</b>
<b>Figure 2.4: Social criteria impacted by each stage of the life cycle (upper) and infrastructure type (lower).....</b>	<b>36</b>
<b>Figure 2.5: Participation in the multi-criteria social assessment of infrastructures .....</b>	<b>37</b>
<b>Figure 2.6: Methods for determining the weights of social criteria.....</b>	<b>39</b>
<b>Figure 2.7: Methods for the social assessment of infrastructure alternatives .....</b>	<b>40</b>
<b>Figure 2.8: Distribution of the treatment of equity in multi-criteria social assessment methods.....</b>	<b>42</b>
<b>Figure 2.9: Distribution of the studies that deal with social learning .....</b>	<b>43</b>
<b>Figure 2.10: Distribution of the treatments for consideration of the context .....</b>	<b>44</b>
<b>Figure 3.1: Research process.....</b>	<b>61</b>
<b>Figure 3.2: Steps in the Delphi method .....</b>	<b>62</b>
<b>Figure 4.1: Development outline of the method .....</b>	<b>80</b>
<b>Figure 4.2: Identification of the trend on sustainability through the Ward dendrogram for the 2014 class (left) and the 2015 class (right) .....</b>	<b>86</b>
<b>Figure 4.3: (a) Alternative 0 (no-project) for case study 1; (b) Alternative 1 for case study 1; (c) Alternative 2 for case study 1 .....</b>	<b>87</b>
<b>Figure 5.1 : Proposed method .....</b>	<b>108</b>
<b>Figure 5.2: Intervening elements for scoring a social criterion in the short term .....</b>	<b>111</b>
<b>Figure 5.3: Determination of variables, weights and transfer functions .....</b>	<b>112</b>
<b>Figure 5.4: Intervening elements in the score contributing to a long-term social goal.....</b>	<b>113</b>
<b>Figure 5.5: Sequence of activities to identify the eligible projects according to their contribution to social sustainability.....</b>	<b>115</b>
<b>Figure 5.6: Decision-making structure of case study .....</b>	<b>118</b>
<b>Figure 5.7: Geographical location of assessment contexts .....</b>	<b>119</b>
<b>Figure 5.8: Socially sustainable solutions.....</b>	<b>126</b>
<b>Figure 6.1: Method for estimating the social contribution considering the uncertainty .....</b>	<b>137</b>
<b>Figure 6.2: Curve of Vi value for high, moderate and low social requirement .....</b>	<b>141</b>
<b>Figure 6.3: Variation of weights obtained in consultation with decision-makers.....</b>	<b>148</b>
<b>Figure 6.4: Accumulated uniform distribution of employment (i=1) and economy (k=1) .....</b>	<b>149</b>
<b>Figure 6.5: Contribution to the social improvement of the infrastructure alternatives in three social requirement scenarios .....</b>	<b>150</b>
<b>Figure 6.6: Improvement of long-term social goals (left) and short-term criteria (right) by infrastructure .....</b>	<b>151</b>
<b>Figure 7.1: Stages of the proposed method .....</b>	<b>162</b>
<b>Figure 7.2: Process for the identification of criteria, decision variables and their causal connection .....</b>	<b>164</b>
<b>Figure 7.3: Selection of the level of impact of a child node with respect to the state of a parent node .....</b>	<b>165</b>

<b>Figure 7.4: Multiple criteria decision-making model of “n” decision variables, “k” criteria and two joint probability variables ST (short-term) and LT (long-term).....</b>	<b>166</b>
<b>Figure 7.5: Background of context of the case study .....</b>	<b>168</b>
<b>Figure 7.6: Steps for the preparation of decision-making model.....</b>	<b>171</b>
<b>Figure 7.7: Decision-making model for the case study .....</b>	<b>174</b>
<b>Figure 7.8: Analysis of eligible alternatives: (a) social contribution limit, (b) ranking of non-inferior alternatives, (c) behavior of the social contribution mean .....</b>	<b>176</b>
<b>Figura 8.1: Estructura generales de resultados de investigación.....</b>	<b>185</b>